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山茶属花粉外壁表面微形态特征的研究*

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摘要：在前人研究的基础上，利用光学显微镜和扫描电镜观察了山茶属 17 个组 34 个代表种（含变种）的花粉形态；按照韦仲新划分山茶属花粉类型的标准，对其进行归类，所有花粉分为 3 类：颗粒状至皱颗粒状纹饰、皱沟状纹饰和穴－网状纹饰；发现 1 种新的花粉类型：拟穴－网状纹饰。本文还对山茶属的某些分类学问题作了初步探讨。

关键词：山茶属；花粉；外壁；微形态；分类
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Study on Micromorphology of Pollen Exine Surface in *Camellia*

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Abstract：Pollen morphology of 34 species（including 2 varieties）representing 17 sections of *Camellia* was examined under light microscope（LM）and scanning electronic microscope（SEM）in this paper. The pollen grains are classified according to the standard of Wei Zhongxin，they belonging to 3 types：granulate to rugulate-granulate，rugulate-fossulate，foveolate-reticulate. A new pollen type，i.e. false foveolate-reticulate，was found and named. Generally speaking，the sculpture difference of various sections is not necessarily larger than that of the same section，for example，in section Paracamellia，the sculpture varies very much from rugulate-fossulate to false foveolate-reticulate，and then to foveolate-reticulate. Showing that it is difficult to elucidate the systematical relationships between different sections by the sculpture of pollen exine surface. Some classification problems of *Camellia* were probed into preliminarily too.

Key words：*Camellia*；Pollen；Exine；Micromorphology；Classification

Camellia，the largest genus of the family Theaceae，is distributed at the two sides of the Tropic of Cancer and it is famous for some important economic plants，such as *C. sinensis*，*C. oleifera* and *C. japonica*. There are 280 species belonging to 20 sections in *Camellia* all over the world. Of them，238 species of 18 sections are distributed in China（Chang & Ren，1998）. So far，the pollen morphology of *Camellia* has received quite a few studies，yet most of them confine to light microscope. Only 48 species of 18 sections were examined under scanning electronic microscope（statistics from the published pollen data of genus *Camellia*）. Obviously，all those are not enough for the general under-

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standing of pollen morphology of *Camellia*. In this paper, the authors examined pollen grains of 34 species representing 17 sections belonging to four subgenera: *Protocamellia*, *Camellia*, *Thea* and *Metacamellia* by LM and SEM, aiming at providing data for studying pollen morphology of *Camellia* systematically in the future. The authors emphasized on the exine surface sculpture, since there are no remarkable differences among various species or even different sections, as far as the exine thickness, the ratios of tectum to columellae and ektexine to endexine are concerned (Wei *et al*, 1992).

1 Materials and Methods

All the pollen grains were obtained from the specimens in the Herbarium of Zhongshan University (SYS) with the exceptions of *C. albogigas* and *C. crapnelliana* which were taken from living plants in the campus of Zhongshan University. The method of Ao Chengqi et Liu Xiaokun (2001) is used to dispose of pollen for examining under LM and measurements of pollen size or exine thickness are based on 20 pollen grains from each collection. For SEM, mature anthers were dipped in acetic acid (40%) for 1d, then into alcohol (95%) for 5 min after that, anthers were opened up on slides. One by one, pollen grains were picked up by the experimenter with a needle, placed on specimen stubs which were covered with double-sided tape, coated with gold-silver alloy, observed and photographed under SEM of model Hitachi S-520.

2 Results

For the same species, pollen grains are almost identical, while observed on different sides (the polar side or equator side), they take on different aspects more or less. Different species can be distinguished from one another through pollen shape and size. Pollen size varies from species to species, from the maximum of 60.2 μm in diameter (*C. krempfii*) to the minimum of 23.5 μm in diameter (*C. shensiensis*). In general, three groups can be divided roughly according to the size: one group are 40 to 60.2 μm in diameter, the second 25 to 40 μm, the third below 25 μm. On the other hand, the exine thickness changes from species to species much less, from the maximum of 2.3 μm (*C. granthamiana*) to the minimum of 1.7 μm (*C. phaeoclada*). Under LM, most of the examined pollens are regular in shape: they are 3-crack round (such as *C. krempfii*, *C. vietnamensis*, *C. nitidissima*), 3-crack right triangle (*C. obtusifolia*) or 3-crack obtuse triangle (*C. tuberculata*) on the polar sides, round (*C. fluviatilis*), ovate (*C. vietnamensis*, *C. tuberculata*), ellipse (*C. nitidissima*) or obtuse triangle (*C. obtusifolia*) on the equator sides. Pollen grains of few species are irregular in shape under LM (*C. caudata*, *C. glaberrima*). Under SEM, they look like globes (e.g. *C. vietnamensis*, plate Ⅰ: 1) or nearly so, and they are usually 3-colporate (plate Ⅰ: 1-14). Only few are irregular in appearance (*C. glaberrima*) and very few are oblate (*C. hiemalis*). Difference among various species is pollen exine surface sculpture besides size, shape and exine thickness. Exine surface micromorphology of pollen grains of 33 species of *Camellia* is listed in table 1 (According to Chang Hungta et Ren Shanxiang (1998)).

3 Discussion and Conclusion

Table 1 Exine surface micromorphology of pollen grains of 33 species in *Camellia* under SEM

Taxon	Exine sculpture	Taxon	Exine sculpture
Sect. Archecamellia		Sect. Pseudocamellia	
C. granthamiana	rugulate-fossulate	*C. szechuanensis*	rugulate-fossulate
C. albogigas	rugulate-fossulate	Sect. Tuberculata	
Sect. Sterocarpus *C. krempfii*	rugulate-fossulate	*C. tuberculata*	rugulate-fossulate
Sect. Oleifera		Sect. Camellia	
C. oleifera	rugulate-fossulate	*C. reticulata*	foveolate-reticulate
C. sasanqua	rugulate-fossulate	*C. saluenensis*	granulate to rugulate-granulate
C. vietnamensis	rugulate-fossulate	*C. hongkongensis*	foveolate-reticulate
C. oleifera var. *monosperma*	rugulate-fossulate	Sect. Brachyandra	
Sect. Furfuracea		*C. pachyandra*	foveolate-reticulate
C. furfuracea	rugulate-fossulate	Sect. Longipedicellate	
C. crapnelliana	rugulate-fossulate	*C. longipetiolata*	granulate to rugulate-granulate
Sect. Paracamellia		Sect. Thea *C. sinensis*	rugulate-fossulate
C. fluviatilis	rugulate-fossulate	Sect. Longissima	
C. phaeoclada	rugulate-fossulate	*C. longissima*	rugulate-fossulate
C. kissi var. *megalantha*	rugulate-fossulate	Sect. Glaberrima	
C. shensiensis	foveolate-reticulate	*C. glaberrima*	rugulate-fossulate
C. hiemalis	rugulate-fossulate	Sect. Theopsis	
C. microphylla	rugulate-fossulate	*C. costei*	granulate to rugulate-granulate
C. maliflora	fasle foveolate-reticulate	*C. nokoensis*	granulate to rugulate-granulate
C. tenii	rugulate-fossulate	Sect. Eriandria	
C. obtusifolia	rugulate-fossulate	*C. caudata*	rugulate-fossulate
Sect. Luteoflora *C. luteoflora*	rugulate-fossulate	*C. melliana*	granulate to rugulate-granulate

（1） Significance of micromorphology characters of pollen exine surface in classification of genus *Camellia* ： as male gametophytes carrying heredity information， pollens are fairly steady in properties at species level， compared with other tissues and organs in plants， so they are very useful in plant taxonomy. For examination under SEM， pollens are often treated through acetolysis method of Erdtman or not treated at all， but either holes come into being where the exine is relatively thin （for example， *C. oleifera* ， plate Ⅲ – D in Wei Zhongxin *et al* ， 1992） or the pollens are shriveled due to dryness （*C. hiemalis* and *C. caudata* in this study）. Another study shows that there are a few differences in shape between pollens treated through acetolysis method of Erdtman and pollens not treated at all. On the polar sides， pollens of *Platycoden grandiflorum* are often quinquangular when treated through acetolysis method of Erdtman， whereas they are polygonal when not treated at all （Wei， 2001）. Therefore when we classify plants （especially plants in *Camellia*） according to pollen morphology， shape of pollen grains is less important than micromorphology characters of pollen exine surface， which are not liable to change on different samples of the same specimen （e.g. *C. caudata* ， plate Ⅲ ： 22， 23） or different populations of the same species （e.g. *C. pachyandra* in this study and study of Wei *et al* （1992））， so it is credible to identify species and probe into relations among species by means of micromorphology characters of pollen exine surface.

（2） There are six pollen types in *Camellia* in terms of Wei Zhongxin， namely rugulate-verrucate ； coarsely warty ； rugulate with beaded muri ； granulate to granulate-rugulate ； rugulate-fossulate ； foveolate-reticulate. After examining pollen grains of 33 species of *Camellia* under SEM， the authors only found the latter 3 types. Of them， rugulate-fossulate is dominant （23 species in all）. 5 species belong to granulate to granulate-rugulate type and the rest are all foveolate-reticulate. Remarkablely， the sculpture of *C. maliflora* is distinctive. Generally, it belongs to foveolate-reticulate, nevertheless, the muri are not flat but crapy. The authors call it false foveolate-reticulate which is a new pollen type between rugulate-fossulate and foveolate-reticulate (Ao *et al*, 2001).

(3) The exine sculpture of *C. melliana* (plate Ⅱ: 2) resembles that of *C. nokoensis* (Plate Ⅲ: 21) very much (granulate to granulate-rugulate), which shows that the two species or the sections where they are are very related.

(4) *C. kissi* var. *magalantha* is a new variety of *C. kissi* found by Chang (1981), but Ming Tienlu treated it as a variety of *C. fluviatilis* (Ming, 1999). While comparing, we can find that *C. kissi* var. *magalantha* is similar to *C. fluviatilis* in pollen exine sculpture. They are all rugulate-fossulate (Plate Ⅱ: 9, 11), different from *C. kissi* whose pollen exine sculpture is rugulate with beaded muri (Wei *et al*, 1992). It is reasonable to treat *C. kissi* var. *magalantha* as a variety of *C. fluviatilis*, a conclusion supporeted by the study on leaf epidermis morphology of *Camellia* (Ao *et al*, 2002).

(5) The pollen of *C. shensiensis* and that of *C. pachyandra* resemble each other in appearance: the exine sculptures are all foveolate-reticulate and the muri are all flat, the holes are like in shape, too (Plate Ⅱ: 12). It seems that *C. shensiensis* and *C. pachyandra* are very related. Actually, in the light of Chang Hungta, the former belongs to Sect. Paracamellia and the latter to Sect. Brachyandra (Chang & Ren, 1998; Chang, 1981); In terms of Ming Tienlu (1999), the former belongs to Sect. Paracamellia and the latter to Sect. Heterogenea. In neither case, the two species are very related, suggesting that there is no evident correlation between pollen types and plant morphology in *Camellia* and pollen types are not in keeping with the sections divided morphologically by Chang Hungda or Ming Tienlu. In fact, early in the 1990s, such a conclusion was drawn by Wei Zhongxin after he examined pollens of 27 species in *Camellia* (Wei *et al*, 1992).

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Vouchers：*C. granthamiana*，Unknown，Zhang Hongda，s.n.；*C. krempfii*，Kuizhou，Sino-Vietnam Exped. 1790；*C. oleifera*，Unknown，Zeng Huaide17006；*C. sasanqua*，Kyoto plant garden，Japan，Zhang Hongda，s.n.；*C. vietnamensis*，Xinyi，Guangdong，Zhang Hongda，s.n.；*C. furfuracea*，Fangcheng，Guangxi ，Zhong Yecong 08008；*C. fluviatilis*，Guilin Institute of Forest Science，Zhao Sikao0051；*C. phaeoclada* Yunnan，Zeng Huaide17064；*C. kissi* var. *megalantha*，Guangxi，Liang Shengye6505258；*C. shensiensis*，Kunming，Xin Jingsan 50453；*C. hiemalis*，Tokyo，Zhang Hongda，s.n.；*C. microphylla*，Lichuan，Jiangxi，Wang Gujin2326；*C. maliflora*，Japan，Zhang Hongda，s.n.；*C. tenii*，Yunnan，Liu Shene22476；*C. obtusifolia*，Guiyang，Li Yongkang7619；*C. szechuanensis*，Sichuan，Fang Wenpei18166；*C. tuberculata* Chongqing，Li Yongkang，s.n.；*C. reticulata*，Lianghe Dachang，Zeng17062；*C. pachyandra*，Menghai，Tan Yongji et Chen Binghuan AO ；*C. nitidissima*；Guangxi，Xie Yongquan，s.n.；*C. longipetiolata*，Xincheng，Zhong Jian900205；*C. sinensis*，Hainan，Zeng Pei13448；*C. longissima*，Longzhou，Guangxi，Liang Shengye7001213；*C. glaberrima*，Jinping，Yunnan，Mao Pinyi 3330；*C. caudata*，Guangdong，Mo Zeqian99；*C. luteoflora*，Chishui，Guizhou，Zeng Fanan81055. *C. costei* Zeng17015，Guangxi；*C. saluenensis*，Yunnan，Zhang Hongda，s.n.；*C. hongkongensis* Japan，Zhang Hongda，s.n.；*C. nokoensis*，Japan，Zhang Hongda，s.n.；*C. melliana*，Fung Hom，A – 283，Guangdong.

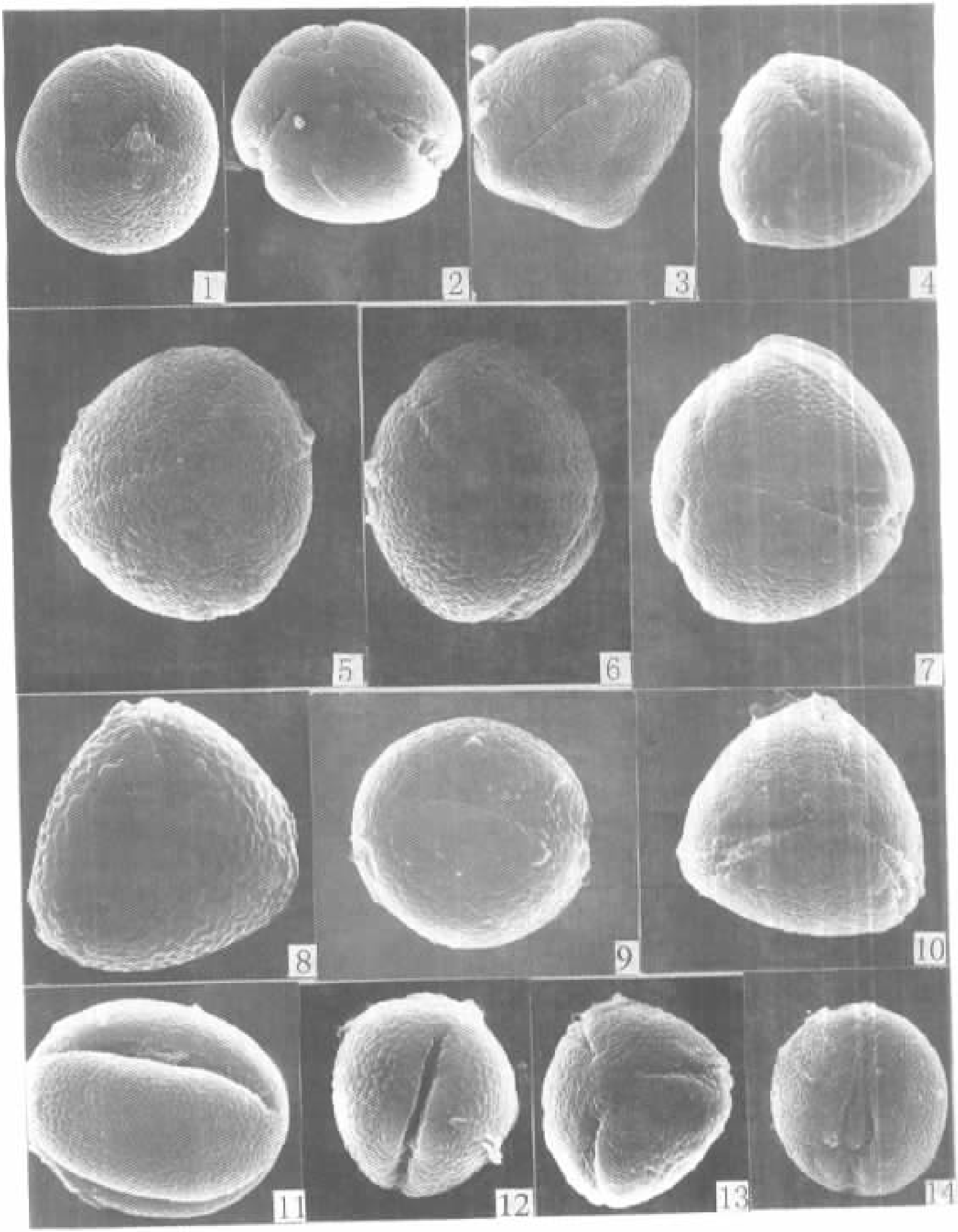
Explanation of Plates

Plate Ⅰ：Morphology of pollen grains in *Camellia* under SEM

1. *C. vietnamensis* × 1 500；2. *C. nokoensis* × 1 500；3. *C. furfuracea* × 1 700；4. *C. saluenensis* × 1 700 ；5. *C. costei* × 1 700 ；6. *C. fluviatilis* × 2 500；7. *C. obtusifolia* × 2 000；8. *C. luteoflora* × 2 200；9. *C. longipetiolata* × 2 000；10. *C. crapnelliana* × 1 700，11. *C. hongkongensis* × 1 700；12. *C. oleifera* × 1 500；13. *C. longissima* × 1 500；14. *C. tenni* × 1 700

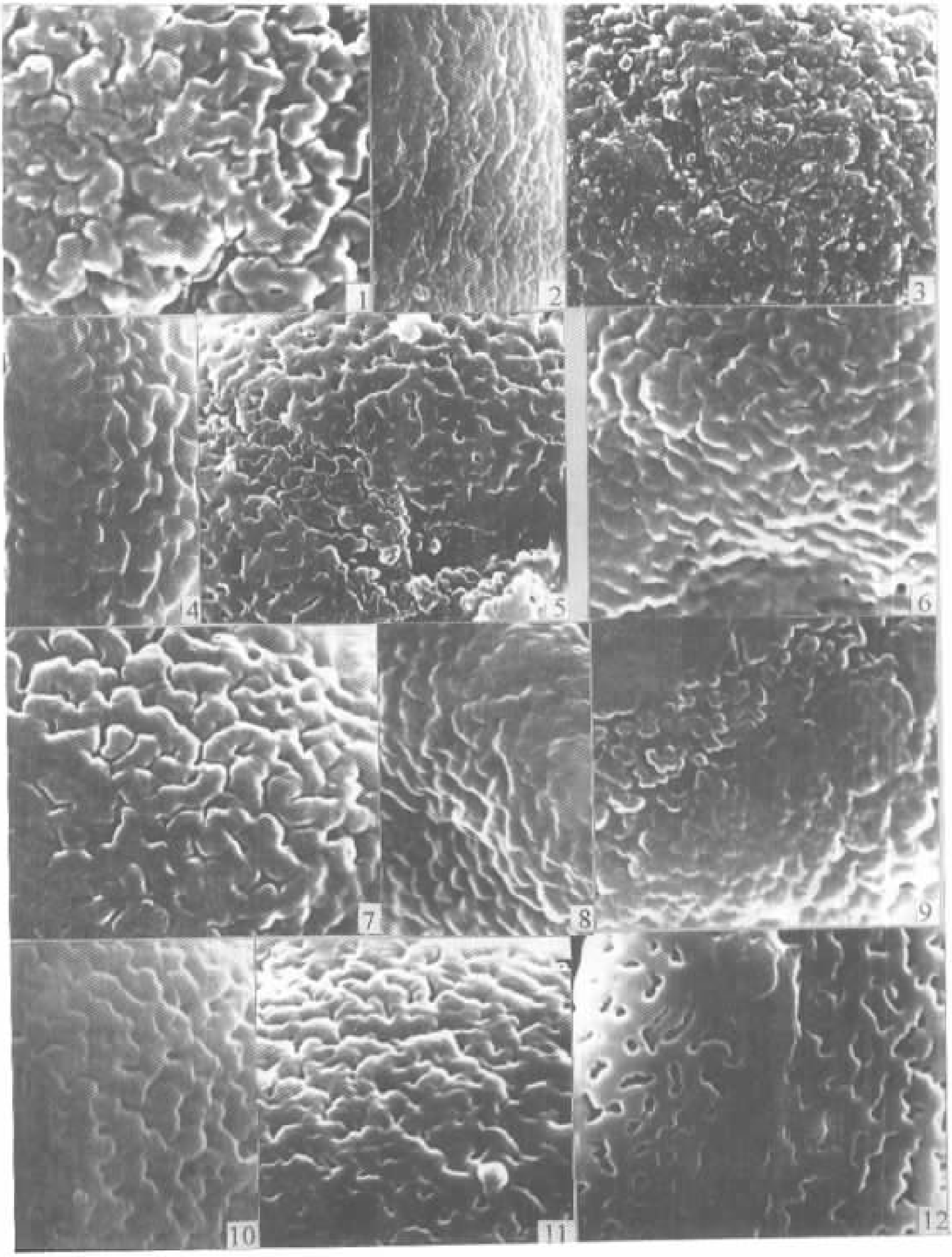
Plate Ⅱ，Ⅲ：Exine surface micromorphology of pollens in *Camellia* under SEM

1. *C. granthamiana* × 8 000，2. *C. melliana* × 7 000，3. *C. costei* × 6 000，4. *C. oleifera* × 5 000，5. *C. vietnamensis* × 6 000，6. *C. oleifera* var. *monosperma* × 8 000，7. *C. furfuracea* × 8 000，8. *C. furfuracea* × 6 000，9. *C. fluviatilis* × 8 000，10. *C. phaeoclada* × 8 000，11. *C. kissi* var. *megalantha* × 8 000，12. *C. shensiensis* × 8 000. 13. *C. hiemalis* × 8 000，14. *C. microphylla* × 8 000，15. *C. maliflora* × 8 000，16. *C. albogigas* × 7 000，17. *C. tuberculata* × 10 000，18. *C. crapnelliana*，× 8 000，19. *C. sinensis* × 8 000，20. *C. longissima* × 8 000，21. *C. nokoensis* × 8 000，22. *C. caudata* × 8 000，23. *C. caudata* × 6 000，24. *C. luteoflora* × 8 000.



敖成齐等： 图版 I

AO Cheng－Qi *et al*: Plate I



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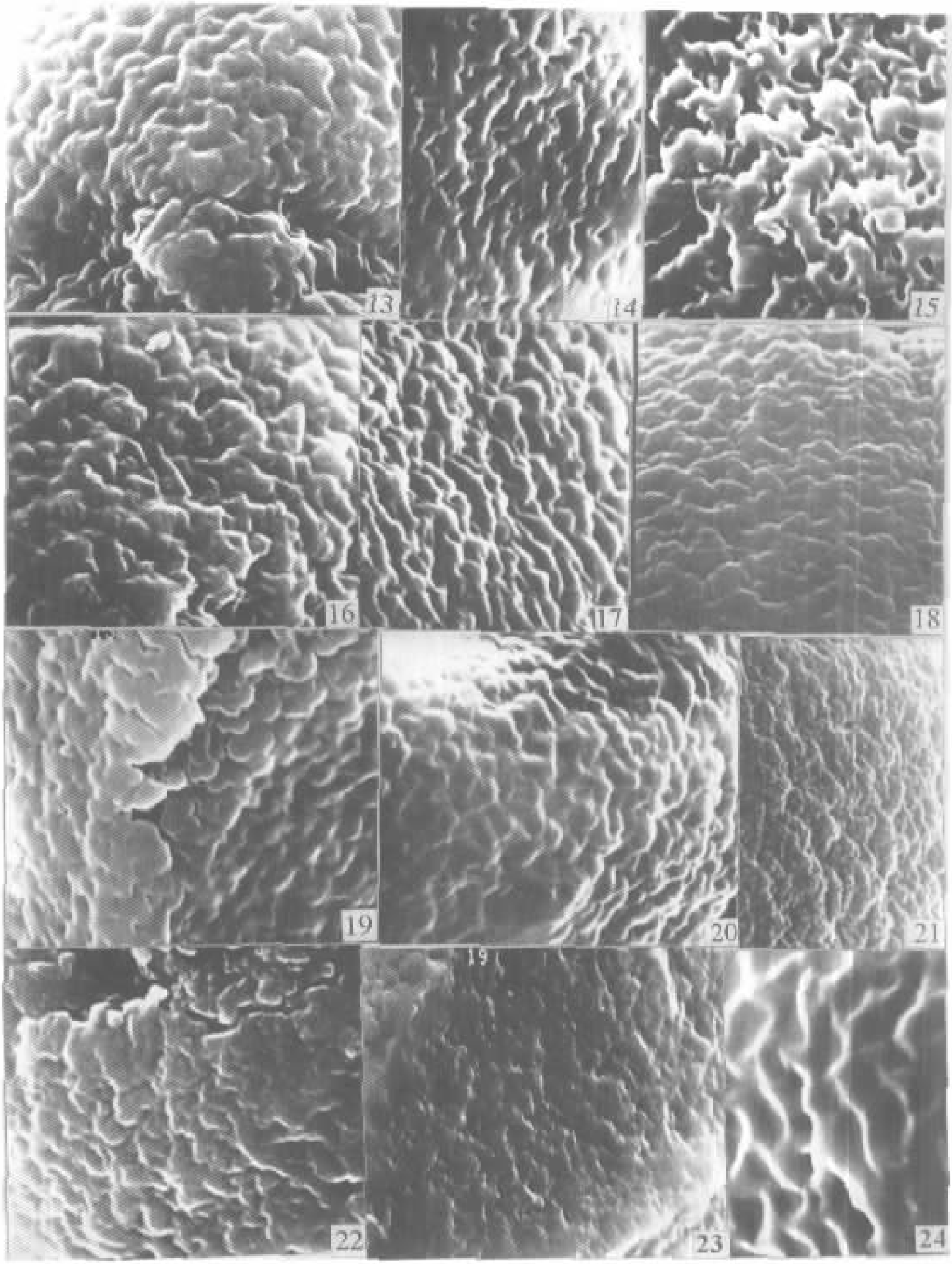

敖成齐等： 图版Ⅲ AO Cheng – Qi *et al*: Plate Ⅲ